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USSR REPORT  
PHYSICS AND MATHEMATICS

No. 76

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## ACOUSTICS

### RELAXATION PROCESSES AND PROPAGATION OF ULTRASOUND IN NEMATIC LIQUID CRYSTALS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 81, No 5(11), Nov 81 (manuscript received 7 May 81) pp 1756-1762

RUBIN, P. L., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] An attempt is made to interpret experimental data on propagation of ultrasound in nematic liquid crystals within the framework of the Mandelstam-Leontovich relaxation theory [see L. D. Landau, Ye. M. Lifshits, "Mechanics of Continuous Media", Moscow, Gostekhizdat, 1944, sections 59 and 60]. Consideration is taken of properties due to anisotropy of liquid crystals. The temperature dependences of acoustic characteristics are not discussed. Temperature is taken as constant and far from the phase transition point. Therefore the influence of fluctuations is disregarded. The proposed theory accounts for the way that pressure and irreversible (viscous) strain tensor depend on the relaxing parameter, causing anisotropy of the speed of sound. Results of calculations are compared with experimental data for methoxybenzylidene butylaniline. Symmetry of kinetic coefficients imposes an additional constraint on the number of independent viscosity coefficients. Figures 3, references 17: 7 Russian, 10 Western.  
[78-6610]

### SOUND ABSORPTION IN METALS ABOVE THE DEBYE TEMPERATURE

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 81, No 5(11), Nov 81 (manuscript received 5 May 81) pp 1860-1871

TRIBEL'SKIY, M. I. and RZHEVSKIY, V. V., Moscow State University  
imeni M. V. Lomonosov

[Abstract] A. I. Akhiezer was the first to undertake a detailed quantum mechanical analysis of sound absorption in metals [see ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, Vol 8, 1938, p 1330]. However, this work did not take account of the change in order of magnitude of the right-hand member of the "electronic" kinetic equation with averaging over the constant-energy surface.

As a result, the description of sound dissipation in metals above the Debye temperature was distorted. In particular, contributions to sound attenuation from viscosity and heat conduction at temperature greater than the Debye temperature were of the same order, and electronic viscosity was always large compared with phonon viscosity, which this paper shows is not the case. It is found in an examination of long-wave sound absorption in a metal single crystal at temperature much greater than the Debye temperature that when electrons are scattered by phonons, absorption is mainly due to electronic heat conduction, and increases linearly with increasing temperature. There is no absorption due to heat conduction in certain directions of propagation and polarization of the sound wave. In these cases, dissipation of sound falls off sharply, absorption is determined by phonon viscosity, and the corresponding coefficient is dependent on temperature, having the same behavior and order of magnitude as in dielectrics. References 6: 5 Russian, 1 Western.  
[78-6610]

UDC 534.231.3

#### DETERMINING IMPEDANCE IN ACOUSTICS OF MOVING MEDIUM

Moscow DOKLADY AKADEMII NAUK in Russian Vol 261, No 1, Nov 81  
(manuscript received 18 May 81) pp 74-78

LYAMSHEV, L. M., Acoustics Institute imeni N. N. Andreyev, USSR Academy of Sciences, Moscow

[Abstract] The concept of impedance in acoustics is defined as the ratio of sound pressure to the normal component of velocity in a planar monochromatic wave. This paper extends the definition to a moving medium. In the proposed approach, it is assumed that a thin sound-transparent membrane that does not distort the flow is at rest in the medium in some plane parallel to the direction of motion of the medium. The surface of this membrane is subjected to normal displacements in the field of the plane monochromatic wave. The impedance redefined in terms of the density and normal velocity component in the medium on the surface of this imaginary membrane enables generalization of many implications of the theory of propagation of plane waves in stationary media to moving laminar media. As examples, the author considers reflection of a plane acoustic wave at the interface of moving homogeneous media, and reflection of a plane acoustic wave from a moving layer that separates two moving media, and a set of layers of moving homogeneous liquids. References 11: 4 Russian, 7 Western.  
[74-6610]

FEASIBILITY OF ACOUSTIC SURFACE WAVE AMPLIFICATION BY ALTERNATING ELECTRIC CURRENT

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 16, No 5, Sep-Oct 81 (manuscript received 12 Mar 81) pp 406-408

SMBATYAN, Zh. Ye., Armenian Pedagogical Institute imeni Kh. Abovyan

[Abstract] Surface acoustic waves can be used in a variety of data processing devices. One interesting application is amplification of ultrasound by supersonic electron drift. Practical utilization of this effect is limited by considerable release of Joule heat, precluding cw amplification. The authors analyze conditions that restrict liberation of Joule heat to a small part of the volume of the specimen, facilitating practical use of the effect. The analysis is based on a model of a semiconductor film of given thickness of cadmium sulfide type with one surface metallized, while the other is pressed against a highly conductive crystal of isotropic or cubic symmetry such as germanium. The film is oriented so that the hexagonal  $z$  axis and the  $x$  axis lie in its plane. A Love wave propagates along the surface of such a laminar structure with given frequency and wave vector on the  $x$ -axis. An external electric field is applied in the direction of the  $y$ -axis, which is the external normal to the film surface. An analytical expression is derived for the gain of the Love wave, and conditions of amplification are determined. The given effect is analogous to amplification by a longitudinal electric field applied in the direction of wave propagation, and is due to the existence of potential wells for electrons in the transverse direction in surface acoustic waves. Although the electric field needed for amplification will be stronger in this case than for longitudinal amplification, a source with relatively low emf can be used since the film can be very thin.

References 2 Russian.

[84-6610]



## CRYSTALS AND SEMICONDUCTORS

### CRYSTAL GROWING IN MODIFIED CZOCHRALSKI-BRIDGMAN-STOCKBARGER GROWTH SYSTEM

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 16,  
No 5, Sep-Oct 81 (manuscript received 21 Jul 80) pp 375-379

NALBANDYAN, O. G. and OVSEPYAN, S. T., Scientific Research Institute of  
Physics of Condensed Media, Yerevan State University

[Abstract] The ratio of diameters of crystal and crucible plays an important part in systems of crystal growing by pulling from the melt. The authors consider the problem of one-dimensional directional crystallization from a melt in the case where the radius of the growing crystal is equal to that of the crucible, and there is a small clearance between the crystal and the walls of the crucible due to the difference in specific volumes of the liquid and solid phases. The feed rate of the crucible is equal to the growth rate of the crystal. This is essentially a combination of the Czochralski and the Bridgman-Stockbarger crystal growing techniques. Hydrodynamic effects due to the difference in densities are disregarded. It is assumed that the melt below a certain level in the crucible is a thermostat with predetermined temperature at the center of the heat zone. The height of the crystallization front above this level is determined by the temperature distribution in the system. The steady-state problem of stability of the crystallization front is solved for random perturbations of parameters of the growth system. The crystallization front is assumed to be planar, heat exchange on the crystal surface is disregarded, and the walls of the crucible are used to account for heat exchange between the melt and the ambient medium. The temperature distribution in the walls of the crucible is found when heat transfer through the upper edge of the crucible is given by Newton's law. It is found that the sensitivity of the growth system with respect to temperature perturbations in the center of the heating zone in the melt during growth by the proposed technique is lower than by the Czochralski method. The given method also has the advantage over the Bridgman-Stockbarger technique that the crystallizing material is not in contact with the crucible walls in the crystallization region. Figure 1, references 2 Russian.

[84-6610]

## ELECTRICITY AND MAGNETISM

### STRONG SCATTERING OF PARTICLES IN RANDOMLY INHOMOGENEOUS MAGNETIC FIELD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 81, No 5(11), Nov 81 (manuscript received 7 May 81) pp 1723-1730

VAYNSHTEYN, S. I. and KICHATINOV, L. L., Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, Siberian Department, USSR Academy of Sciences

[Abstract] A kinetic equation is derived that describes propagation of charged particles in an electromagnetic field with random inhomogeneities in intense scattering. The formulated problem is analogous to the theory of strong scattering of electromagnetic waves, and to the problem of hydrodynamic turbulence, where there is no small parameter. Solution of the problem is based on Orszag's approach [see S. A. Orszag, JOURNAL OF FLUID MECHANICS, Vol 41, 1970, p 363], which yields the Kolmogorov spectrum in hydrodynamic turbulence theory. At the weak scattering limit, the derived equation is automatically transformed to previously found results. The proposed method improves on Orszag's scheme in the fact that an equation is derived for the memory time of the system  $\tau$ , rather than merely assigning this parameter. The proposed kinetic equation is valid even when the particle scattering angle on the correlation length of the magnetic field is not small. An examination is made of the diffusion approximation with consideration of particle acceleration by a stochastic electric field. References 12: 6 Russian, 6 Western.

[78-6610]

## NONEQUILIBRIUM VIBRATIONAL MOLECULAR EXCITATION BEHIND SHOCK WAVE FRONT IN CASES

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
No 5(129), Sep-Oct 81 (manuscript received 25 Jun 80) pp 49-54

DOBKIN, S. V. and SON, E. Ye., Moscow

[Abstract] Previous research has shown that when a shock wave propagates through a light gas doped slightly with a heavy gas, the length of translational relaxation of the heavy molecules is approximately  $m_G/m_L$  times longer than for the light molecules (where  $m_G$  and  $m_L$  are the masses of the heavy and light components). This is because a large number of collisions is needed to slow down a heavy particle. In this paper, a qualitative analysis is made of phenomena that take place in deceleration of a molecule made up of atoms with masses  $m_H$  and  $m_F$  in a medium of particles of mass  $m_L$  ( $m_H \gg m_F \gg m_L$ ). The fraction of vibrational energy transmitted to the molecule as it is decelerated in the light gas is calculated, and an examination is made of relaxation of the vibrational energy of molecules described by harmonic oscillators in the zone of deceleration in the light gas behind the shock wave front. It is shown that shock wave propagation in such a medium may be accompanied by a process of "nonequilibrium" excitation of the heavy gas molecules in which the vibrational temperature may rise to levels that exceed the gas temperature behind the shock wave front in contrast to the equilibrium case. An example of calculation of the vibrational energy in a shock wave in a mixture of helium with uranium hexafluoride is given. The possibility of experimental confirmation is discussed. Figures 2, references 7: 5 Russian, 2 Western.

[70-6610]

## ANOMALOUS RELAXATION AND INSTABILITY OF SHOCK WAVES IN GASES

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 11, Nov 81  
(manuscript received 24 Dec 80) pp 2315-2324

MISHIN, G. I., BEDIN, A. P., YUSHCHENKOVA, N. I., SKVORTSOV, G. Ye. and  
RYAZIN, A. P., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy  
of Sciences, Leningrad

[Abstract] The paper discusses phenomena observed in intense shock waves propagating in a variety of gases under a wide range of conditions in experiments on the ballistic facility of the Physicotechnical Institute imeni A. F. Ioffe, on the jet-vacuum installation at the Institute of Chemical Physics, and on the shock tube at the Physics Department of Moscow State University. The new effects that have been observed are called anomalous relaxation in shock waves, distinguished from ordinary dissipative relaxation by intensification of perturbations of gasdynamic quantities and an increase in the degree of nonequilibrium. Systematic results are given that demonstrate anomalous relaxation in shock waves as manifested in the following effects: perturbation and destruction of the shock wavefront; chaotic perturbations of the relaxation zone, nonmonotonic variation of observed quantities with increasing distance from the front; pressure increase behind the shock in counter interaction; increased heat release behind the shock wave; increased drag; emission anomalies. A theoretical interpretation of anomalous relaxation is given in which it is assumed that the effect arises when certain conditions are met: 1. sufficient intensity of the shock wave; 2. considerable internal energy of excited particles; 3. "moderate" densities; 4. elementary processes under the conditions that arise behind the shock wave in the given gas or mixture ensuring realization of certain stages--accumulation of shock-wave energy by excited particles, transformation of this energy to a form favorable for transition to kinetic energy, and rapid T-deactivation of these particles. A quantitative analysis of critical conditions is given for inert gases. Figures 7, references 15: 12 Russian, 3 Western.  
[66-6610]

UDC 533.6.011.72

POLYATOMIC DIPOLE MOLECULE VIBRATIONAL LEVEL POPULATION INVERSION BEHIND  
SHOCK WAVE FRONT

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
No 5(129), Sep-Oct 81 (manuscript received 18 Jun 80) pp 54-61

LEVIN, V. A. and STARIK, A. M., Moscow

[Abstract] Previous research has demonstrated the feasibility of population inversion when thermodynamic equilibrium is disturbed by an abrupt increase in temperature of a mixture of polyatomic molecules having different times of relaxation of normal vibrations. Minimum vibrational-translational relaxation times are typical of asymmetric dipole molecules, and the use of such molecules also gives acceptable gains even with low density of inversely populated particles. In this paper, the authors continue their investigation of the water-vapor laser using rapid heating by shock waves [see V. A. Levin, A. M. Starik, "Vibrational Energy Exchange in  $H_2O-H_2$  Mixtures in Shock Waves", IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA, No 1, 1979]. An analysis is made of propagation of direct shock waves in media containing molecules of  $H_2O$ ,  $H_2$  and  $O_2$ . The influence that  $H_2$  and  $O_2$  impurities have on inversion characteristics is considered. Analysis shows that a gasdynamic water-vapor laser based on the principle of rapidly increasing translational temperature in shock waves could be an intense source of coherent emission in the near infrared ( $\lambda \sim 10.6 \mu m$ ) with gain reaching  $1.5 m^{-1}$ , and specific radiation energy of 30 J/g. Figures 4, references 24: 10 Russian, 14 Western. [70-6610]



## SETTLING OF OSCILLATIONS IN FREE-ELECTRON LASERS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 11, Nov 81  
(manuscript received 25 Mar 81) pp 2452-2454

CHETVERIKOV, A. P., Saratov State University imeni N. G. Chernyshevskiy

[Abstract] Since free-electron lasers are stimulated by current pulses of duration comparable with that of the transient process, it is important to be able to determine the settling time of steady-state oscillations. In this paper it is shown that settling of single-frequency oscillations in the free-electron laser under conditions of excitation of many longitudinal modes of the cavity takes place in two stages: first the amplitude of the fundamental mode is established along with phase relations between modes, and then slow damping of extraneous modes occurs. Therefore in the case of limited current pulse durations, the output signal of the free-electron laser will appear nearly the same as a multifrequency waveform even when the beam current slightly exceeds the starting current. Linear and nonlinear stages of the transient process are considered separately. References 4 Russian.  
[66-6610]

## THEORY OF STIMULATED EMISSION ON SECOND HARMONIC OF INTENSE LASER RADIATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 261, No 4, Dec 81  
(manuscript received 5 Jun 81) pp 846-850

IBRAGIMOV, E. F. and USMANOV, T., Institute of Electronics imeni U. A. Arifov, UzSSR Academy of Sciences, Tashkent

[Abstract] Laser fusion research relies on efficient conversion of neodymium laser emission to the second harmonic, as short-wave emission has certain advantages over the fundamental radiation of the laser. This has necessitated a detailed study of stimulated emission of the second harmonic under real conditions to ascertain the limits of efficient conversion. The theories of stimulated emission of the second harmonic that have been developed so far give a good description of the pattern of nonlinear interaction under actual conditions only in the case of weak energy interchange of waves or in certain special cases. However, from a practical standpoint the most interesting cases are those of strong energy exchange between waves for arbitrary phase and amplitude profiles of the beam at the input to the nonlinear medium. Therefore the authors develop a theory of second harmonic emission in the case of strong energy exchange between interacting waves under realistic conditions based on solving nonlinear equations by a method of successive approximations. The

capabilities of the proposed method are illustrated by a system of equations that describes stimulated emission of the second harmonic in media with dispersion. It is shown that conversion efficiency may be considerably limited in the case of minor phase modulation of the input radiation even when the length of the nonlinear medium is much shorter than

$$\tau \left( \frac{1}{u_1} - \frac{1}{u_2} \right)^{-1}, \text{ where } \tau \text{ is duration}$$

of the pumping pulse,  $u_1$  and  $u_2$  are the group velocities of the interacting waves. Figure 1, references 9: 8 Russian, 1 Western.

[87-6610]

UDC 621.376.826

#### CALCULATING PARAMETERS OF OPTICALLY PUMPED COLLISIONAL LASERS BASED ON SELF-LIMITING TRANSITIONS

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 5, Sep-Oct 81  
(manuscript received 29 Apr 80) pp 937-944

BATENIN, V. M., GOLGER, A. L. and KLIMOVSKIY, I. I., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] This article continues research by these authors begun in KVANTOVAYA ELEKTRONIKA, Vol 6, No 5, 1979, p 1077 demonstrating the feasibility of cw lasing on self-limiting transitions with optical pumping. An analysis is made of the parameters of the optical pumping system, laser efficiency and output power are evaluated, and optimum working conditions are determined. It is assumed that depopulation of the lower (metastable) laser levels in the active medium is due to inelastic collisions of the second kind  $A(1^a) + B(0^b) \rightarrow A(0^a) + B(1^b)$ . The lasing volume and optical pumping device are separated by a barrier that is transparent to the pumping radiation. The active medium is a mixture of atoms of the working gas (type A) having resonant ( $0^a \rightarrow 2^a$ ) and self-limiting ( $2^a \rightarrow 1^a$ ) transitions, and atoms of type B that effectively depopulate the metastable level  $1^a$  of the working atoms in the collisional process. The same atomic gas type A is used in the pumping device as in the active medium. Thus an electric discharge in the pumping system excites atoms of type A to the resonant state  $2^a$  that decays mainly through channel  $2^a \rightarrow 0^a$  due to spontaneous emission that passes through the transparent barrier, producing optical pumping of the active medium. Figures 2, references 9: 6 Russian, 3 Western.

[64-6610]

## FEASIBILITY OF FREQUENCY TUNING OPTICALLY PUMPED SUBMILLIMETER MASERS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 5, Nov 81  
(manuscript received 28 May 80) pp 870-874

YEFREMOV, V. A. and DYUBKO, S. F.

[Abstract] The authors consider the principle of two-photon resonance as applied to a four-level model of the active medium (see diagram) in which electro-dipole transitions  $1 \leftrightarrow 4$ ,  $2 \leftrightarrow 3$ ,  $4 \leftrightarrow 3$  and the two-quantum transition  $2 \leftrightarrow 4$  are allowed. Under the action of pumping frequency  $\omega_1$  resonant to rotational-vibrational transition  $1 \leftrightarrow 4$ , purely rotational transitions  $3 \leftrightarrow 4$ ,  $2 \leftrightarrow 4$  are inverted, and consequently if this medium is placed in cavities tuned to frequencies  $\omega_1$ ,  $\omega'$  (or in a single two-frequency cavity), cascade  $2 \leftrightarrow 3 \leftrightarrow 4$  and two-quantum  $2 \leftrightarrow 4$  transitions are possible that satisfy condition  $\hbar\omega' + \hbar\omega_2 = \hbar\omega_{24}$ . In the case  $\omega' = \omega_{34}$ ,  $\omega_2 = \omega_{24}$  when cascade transitions predominate, the maser is readily excited. If the frequencies of both oscillators are shifted by an amount  $\Omega'$  to preserve condition  $\omega' + \omega_2 = \omega_{24}$ , two-photon resonance can be said to take place at a sufficiently great mismatch if the oscillator is still operating. However, triggering is difficult in this case since the probability of two-quantum transitions is proportional to the product of the number of quanta  $\hbar\omega'$  and  $\hbar\omega_2$ . Triggering is facilitated by injecting an intense stream of quanta on frequency  $\omega_2$  lying in the millimeter band where efficient emission sources are available for wide-range tuning. The gain (or absorption) is found for a weak wave  $\vec{E}'$  on transition  $3 \leftrightarrow 4$  with pumping of a four-level gas by two monochromatic fields resonant to transitions  $1 \leftrightarrow 4$ ,  $2 \leftrightarrow 3$ . A specific analysis is done for formic acid as a working medium and it is demonstrated that the proposed technique can give a tuning band of up to 0.5 GHz.



Figures 3, references 5: 4 Russian, 1 Western.  
[90-6610]

UDC 621.311.29:536.1

INFLUENCE OF SECONDARY FLOW CAUSED BY HALL CURRENTS IN COMPRESSED BOUNDARY LAYERS CLOSE TO INSULATOR WALL IN MHD GENERATOR

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 5, Sep-Oct 81  
(manuscript received 1 Oct 80) pp 1078-1082

SAT'YAMURTI, P., VENKATRAMANI, N. and ROKHATGI, V. K., Baba Nuclear Research Center, Bombay

[Abstract] The working characteristic of MHD generators is influenced by growth of the boundary layer along the electrode and insulation walls. Friction in the wall layer, heat flux to the wall and electrical losses are localized in this region. The authors analyze phenomena that take place in the boundary layer along the insulator wall with consideration of transverse flow caused by Hall currents. A detailed investigation is made of compressible turbulent flow of combustion products with an additive for a small experimental generator in which negligible transverse flow is expected, and for the bypass loop of the U-25 facility where the influence of transverse flow should be greater and closer to industrial generators. The following assumptions are made: flow is steady-state; only time-averaged parameters are used; the plasma is made up of water gas combustion products with potassium additive burned in air with 40% oxygen enrichment; the plasma is in total local thermodynamic equilibrium; all reactions have an infinite rate; plasma radiation is negligible compared with convective heat transport; the thickness of the boundary layer is less than the distance between electrodes, so that the problem can be taken as planar. Numerical analysis of the boundary layer is based on the Patankar-Spalding method. The results show that transverse flow reaches maximum velocity right at the wall, where it is about 5% of the axial flow velocity in the U-25B facility. It is assumed that this will be the case for all large industrial MHD generators. Figures 8, references 9 Western.  
[64-6610]

## NUCLEAR PHYSICS

### HYDRODYNAMIC MODEL OF PLASMA 'CORONA' PRODUCED WHEN CHARGED PARTICLE BEAMS ACT ON TARGET

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 81, No 5(11), Nov 81 (manuscript received 21 Apr 81) pp 1714-1722

AFANAS'YEV, Yu. V., ISAKOV, V. A. and KROKHIN, O. N., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] As in laser-driven fusion, inertial implosion by ion beams involves three stages: formation of a corona with energy transfer to the unvaporized part of the target, compression, and thermonuclear ignition. Although there are some qualitative differences, a hydrodynamic model of the corona can be constructed in analogy to the laser fusion case based on simple assumptions about input of ion beam energy into a plasma. In this paper the authors examine some models that describe plasma formation when a beam of charged particles acts on flat and spherical targets. Physical parameters are defined in analytical form that characterize the process of vaporization and energy transfer to the unvaporized part of the target. A criterion is derived for equivalence of ion and laser beams in inertial nuclear fusion. Figures 2, references 13: 8 Russian, 5 Western.  
[78-6610]

UDC 621.384.64

### ION FOCUSING EFFICIENCY IN LINAC BY TRAVELING WAVE FIELD

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 11, Nov 81 (manuscript received 15 Jan 80, after revision 26 Aug 80) pp 2310-2314

BAYEV, V. K. and MINAYEV, S. A.

[Abstract] An investigation is made of a method of particle focusing by an accelerating field proposed by V. S. Tklich [ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, Vol 32, 1957, p 625]. The technique is called acceleration with focusing by traveling wave field, and has been demonstrated to be feasible in an extensive class of structures. The analysis is based on



equations of motion of ions in the non-relativistic approximation. Conditions of longitudinal and transverse stability of ions are found, the region of phase stability and rate of acceleration are determined, and the limiting current is estimated. It is shown that a large group of ions can be accelerated in such a linac in the two-meter range. It is shown that this focusing method has distinct advantages for heavy-ion linacs, and it is suggested that more attention should be given to focusing by traveling wave field despite the advances that have been made in rf quadrupole and phase-variable focusing. Figures 2, references 12 Russian.

[66-6610]

#### IODINE NANOSECOND PULSE AMPLIFIER WITH 2 kJ EMISSION ENERGY IN ONE BEAM

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 7, No 22, 26 Nov 81 (manuscript received 25 Jul 81) pp 1368-1372

GASHEYEV, A. S., ZARETSKIY, A. I., KIRILLOV, G. A., KORMER, S. B., KUZ'MICHEV, Yu. P., KURATOV, Yu. V., KUCHEROV, A. I., MURUGOV, V. M., NITOVCHIN, N. A., RUKAVISHNIKOV, N. N., RYADOV, A. V., SAMYLIN, V. A., SUKHAREV, S. A. and SHEMYAKIN, V. I.

[Abstract] As part of inertial fusion research, the authors have developed a multistage laser facility that gives output energy of 1.8 kJ in one channel (2.1 kJ at the output from the medium). The facility is made up of a master oscillator, two preamplifiers and two final stages. The master amplifier and preamplifiers are based on flash-pumped quartz cells. The final stages maximize output energy in the monopulse amplification mode. The prefinal stage has a light diameter of 300-400 mm and length of the active medium of 4 m, and the final stage has a light diameter of 700 mm and length of the active medium of 8 m. The working fluid for all stages is  $C_3F_7I$  mixed with different buffer gases:  $CO_2$ , Ar and  $SF_6$ . The pressure of the components in the final power stages was selected to give a weak-signal gain of about 100. Energy contrast at the output is at least  $4 \cdot 10^5$ . Output pulse duration is no more than 0.7 ns at half-amplitude, and the light diameter of the output beam is 58 cm with fairly uniform structure over the entire aperture. Beam divergence is about  $3 \cdot 10^{-4}$  rad with respect to 80% energy, and is due chiefly to aberrations of the optical elements and divergence of the input signal. Figures 2, references 6: 5 Russian, 1 Western.

[82-6610]

ALFVEN WAVE HEATING OF NONCONDUCTING THREE-COMPONENT PLASMA IN URAGAN-2 STELLARATOR

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 34, No 10, 20 Nov 81 (manuscript received 8 Sep 81) pp 533-536

SHVETS, O. M., KALINICHENKO, S. S., LYSOYVAN, A. I., NAZAROV, N. I.,  
SLAVNYY, A. S., STEPANOV, K. N. and TARASENKO, V. F. (deceased),  
Physicotechnical Institute, UkSSR Academy of Sciences

[Abstract] An investigation is made of the use of ion cyclotron resonance for heating a plasma in fusion research. The technique relies on a linear collisionless mechanism of energy transfer from an applied rf field to a small group of resonant ions with subsequent heating of the principal (nonresonant) component through Coulomb collisions. Experiments show anomalously fast (collisionless) heating of a hydrogen plasma doped with up to 10% deuterium ions under the action of Alfvén (ion cyclotron) waves. The experiments were done on the Uragan-2 racetrack stellarator. It is shown that a nonconducting dense plasma (density of the order of  $10^{13} \text{ cm}^{-3}$  or more) can be produced and heated by combined operation of two rf oscillators on different frequencies. Figures 3, references 6: 5 Russian, 1 Western.

[89-6610]

UDC 621.378.5:551.508.769

## LASER ABSORPTION DIAGNOSIS OF ATMOSPHERIC GASES

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 35, No 5, Nov 81  
(manuscript received 10 Dec 80) pp 785-790

MAKUSHKIN, Yu. S., MITSEL', A. A. and KHMEL'NITSKIY, G. S.

[Abstract] A method is described for checking the integral concentration of gases in the atmosphere by using a tunable CO<sub>2</sub> laser. The technique is based on determining the molecular absorption of the laser emission. Probing data are analyzed by using the following relation between the volumetric coefficient of attenuation  $\alpha(\lambda)$  on wavelength  $\lambda$  and the integral concentration of gases:

$$\alpha(\lambda) = \sum_{i=1}^m K_i(\lambda) \rho_i + \alpha_{\text{cont}}(\lambda),$$

where  $m$  is the number of gases that absorb radiation on the given wavelength,  $K_i(\lambda)$  is the mass coefficient of absorption of the  $i$ -th gas on this wavelength,  $\rho_i$  is the concentration of the  $i$ -th gas averaged over the transmission path of the laser beam,  $\alpha_{\text{cont}}(\lambda)$  is the coefficient of continuous nonselective attenuation due to aerosol particles and possible molecular absorption by the wings of far lines of other gases. A statistical criterion is used for selecting the parameter of regularization. Gas concentrations determined by the proposed method are compared with the results of numerical calculations for H<sub>2</sub>O, CO<sub>2</sub>, NH<sub>3</sub>, O<sub>3</sub>, C<sub>2</sub>H<sub>4</sub> and C<sub>6</sub>H<sub>6</sub>. Agreement is satisfactory for practical purposes. Figures 2, references 13: 10 Russian, 3 Western.  
[60-6610]

## WAVEFRONT REVERSAL WITH INDUCED SCATTERING OF ULTRAVIOLET RADIATION

Moscow DOKLADY AKADEMII NAUK in Russian Vol 261, No 1, Nov 81  
(manuscript received 19 Jun 81) pp 71-74

BELOUSOV, V. N., NIZIYENKO, Yu. K., PILIPETSKIY, N. F. and RAGUL'SKIY, V. V.,  
Institute of Problems in Mechanics, USSR Academy of Sciences, Moscow,  
Institute of Atomic Energy imeni I. V. Kurchatov, Moscow

[Abstract] An experimental investigation is made of the feasibility of wavefront reversal by stimulated scattering of ultraviolet radiation. A neodymium laser beam is converted to the fourth harmonic by KDP crystals, giving a linearly polarized beam with wavelength of  $0.2635 \mu\text{m}$ , pulse duration 20 ns, peak power 20 MW, divergence  $3 \cdot 10^{-4}$  rad, spectral width less than  $3 \cdot 10^{-3} \text{ cm}^{-1}$ . This beam is passed through a phase plate and focused by a lens into a fused quartz rod. The phase plate narrowed divergence without affecting linear polarization. This arrangement produced stimulated Mandelstam-Brillouin scattering in the fused quartz. The angular, spectral and time characteristics of the stimulating and scattered light were measured. It was found that the divergence of the scattered light after passing through the phase plate practically coincided with the divergence of the initial fourth harmonic beam, showing wavefront reversal. Careful interferometric measurements showed that the frequency shift with induced Mandelstam-Brillouin scattering is  $\Delta\nu = 2.246 \pm 0.006 \text{ cm}^{-1}$ . This implies that the velocity of hypersound on 68 GHz at  $20^\circ\text{C}$  in fused quartz is  $5906 \pm 15 \text{ m/s}$ , which agrees well with data for spontaneous scattering spectra in the 19-52 GHz range. Figures 3, references 7: 5 Russian, 2 Western. [74-6610]

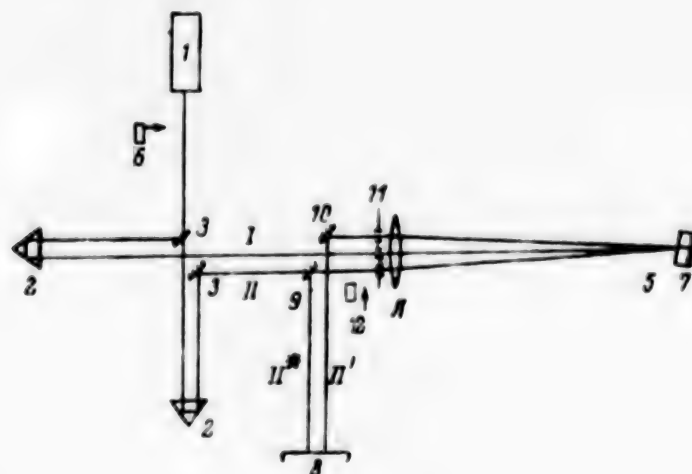
## PICOSECOND PULSE WAVEFRONT REVERSAL WITH FOUR-WAVE INTERACTION IN LITHIUM NIOBATE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 7, No 22,  
26 Nov 81 (manuscript received 9 Sep 81) pp 1365-1368

ALUM, Kh. P., VLAD, I. V., DABU, R., KOVAL'CHUK, Yu. V., OSTROVSKAYA, G. V.  
and OSTROVSKIY, Yu. I., Physicotechnical Institute imeni A. F. Ioffe,  
USSR Academy of Sciences, Leningrad

[Abstract] A report on observation of wavefront reversal of picosecond pulses emitted by a  $\text{YAG:Nd}^{3+}$  laser operating on the second harmonic with four-wave interaction in a lithium niobate crystal. A scheme is proposed for using wavefront reversal to study the dynamics of rapidly occurring processes. The experimental setup is shown in the diagram. The  $\text{YAG:Nd}^{3+}$  picosecond laser (1) emitted isolated pulses ( $\lambda = 1.06 \mu\text{m}$ ) with duration of 60 ps and energy of about  $3 \cdot 10^{-4} \text{ J}$ . The system of prisms (2) and mirrors (3) produced two parallel light beams intersecting at the focus of lens (4) ( $f = 50 \text{ cm}$ ). The path

difference was compensated by shifting one of the prisms (2) and monitored with respect to generation of the harmonic with noncollinear interaction in lithium niobate crystal (5). The same effect was used for measuring pulse duration. The crystal was placed with the input face normal to reference beam I and turned  $90^\circ$  around the optical axis of this beam, serving as a medium for recording dynamic holograms and studying the second harmonic of laser pulses with wavelength of  $0.53 \mu\text{m}$  stimulated in a second lithium niobate crystal (6) placed in the laser beam. Crystal (5) was placed so that the laser beams were focused near its rear face. A flat mirror (7) against the back of this crystal and normal to the axis of reference beam I produced a reading beam conjugate to the reference beam. The dynamic hologram in the lithium niobate crystal reconstructed wave  $\text{II}^*$  conjugate to object wave II. Film (8) recorded this wave and comparison object wave  $\text{II}'$  reflected from mirror (7) and passed through lens (4). Mirrors (9) and (10) diverted the reversed and comparison waves to the film. The results show efficiency of wavefront reversal (ratio of intensity of the reversed wave to the intensity of the reference beam) of about 0.5% at a distance of 3 meters from crystal (5). To check phase conjugation, an inhomogeneous plate of acrylic plastic (12) was placed in the path of the object beam, and analogous photographs were taken at a distance of 1 meter from the crystal. The results show complete compensation of phase distortions with almost no increase in the diameter of beam  $\text{II}^*$ , while the comparison beam was appreciably broadened. This setup could be used for studying rapid changes that occur with phase inhomogeneity over the time of light beam travel to mirror (7) and back, from a fraction of a nanosecond to tens of nanoseconds. Figures 2, references 8: 5 Russian, 3 Western.



[82-6610]



UDC 543.53:666.192-621.372.8:621.315.61

## NEUTRON-ACTIVATION ANALYSIS OF IMPURITIES IN QUARTZ GLASSES USED IN INTEGRATED OPTICS

Moscow DOKLADY AKADEMII NAUK in Russian Vol 261, No 1, Nov 81  
(manuscript received 1 Jun 81) pp 83-85

PETROVSKIY, G. T., associate member, USSR Academy of Sciences, SOROKA, A. V.,  
CHERENDA, N. G. and YUDIN, D. M.

[Abstract] One method of producing integrated optics components is to expose quartz glass to ionizing radiation. Uncontrolled impurities in the material fix the energy introduced by irradiation, leading to formation of color centers and associated radicals. To get the most complete information on the composition of trace impurities in different grades of quartz glass, the authors develop a technique based on neutron-activation analysis for determining trace impurities in KI, KV, KU-1 and KU-2 industrial quartz glasses with high sensitivity. The elemental makeup of the phenolformaldehyde resin standards was known within 1-2% with content of individual elements of  $10^{-4}$ - $10^{-6}$  g per gram of the standard. The study specimens were irradiated simultaneously with the standard in the vertical experimental channel of the IRT-M reactor at the Institute of Atomic Energy. Thermal neutron flux at the point of irradiation was  $10^{13} \text{ (cm}^2 \cdot \text{s)}^{-1}$ . The gamma spectrometer was made up of a Ge(Li) detector (resolution 5.5 keV at  $E_\gamma = 1332 \text{ keV}$ ) and a NOKIA 800-channel amplitude analyzer. The resultant spectra were processed by the UPEAK program on the Minsk-32 computer. Output data on energies and intensities of gamma lines were used to identify trace impurities and determine their quantitative characteristics. This technique enables determination of 18 elemental impurities in quartz glasses. Table 1, references 12: 8 Russian, 4 Western.  
[74-6610]

PARTICULARS OF RECORDING OPTICAL INFORMATION IN ELECTRIC FIELD IN BISMUTH SILICATE AND GERMANATE SINGLE CRYSTALS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 7, No 22, 26 Nov 81 (manuscript received 14 Aug 81) pp 1384-1388

KATSAVETS, N. I. and LEONOV, Ye. I., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] An investigation is made of the way that diffraction efficiency depends on applied voltage in a metal-Bi<sub>12</sub>Si(Ge)O<sub>20</sub>-metal structure, and some of the particulars of photocurrent of such a structure are studied. The structures were made with undoped Bi<sub>12</sub>SiO<sub>20</sub> and Bi<sub>12</sub>GeO<sub>20</sub> single crystals measuring 5 x 5 x 5 mm. The vector of the holographic grating lay in plane [100] parallel to direction [110] and to the vector of the external electric field. The contacts were silver paste and aluminum electrodes applied to the surface of the crystal by vacuum sputtering. The holographic grating was recorded by He-Cd laser with wavelength corresponding to the absorption arm of bismuth silicate and germanate ( $\lambda = 0.44 \mu\text{m}$ ), and readout was by He-Ne laser ( $\lambda = 0.63 \mu\text{m}$ ). Plots are given of the square root of diffraction efficiency as a function of the voltage applied to the structure at different levels of intensity of the recording emission. At a certain voltage, all curves become linear. Extension of the straight sections of the curves to intersection with the axis of abscissas shows convergence at a single point corresponding to 200-400 V, depending on the specimen. To explain this cutoff voltage, an investigation was made of the dependence of photocurrent on applied voltage with stimulation by He-Cd laser emission. The results show that at voltages across the structure in excess of  $U_c + U_d$  (where  $U_c$  is the cutoff voltage and  $U_d$  is the amplitude of potential modulation within the semiconductor volume due to diffusion of photoelectrons), the square root of diffraction efficiency depends linearly on the electric field in the crystal. Displacement of the cutoff voltage along the axis of abscissas is due to contact regions with majority carrier depletion. Figures 2, references 11: 2 Russian, 9 Western.  
[82-6610]

STRESS CONCENTRATOR INFLUENCE ON OPTICAL SURFACE QUALITY OF COOLED POWER OPTICS COMPONENTS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 7, No 22, 26 Nov 81 (manuscript received 2 Oct 81) pp 1388-1392

APOLLONOV, V. V., PROKHOROV, A. M., KHOMICH, V. Yu. and CHETKIN, S. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Work with cooled power optics components has shown considerable deterioration of optical surface quality after a reflector has been operated for some time in a medium with slowly changing temperature (times of ambient temperature variation such that temperature gradients arising in the material

of the structure are negligible). The authors analyze this effect, assuming that the cause of the deterioration is to be found in the concentration of temperature stresses on the faces and edges of porous heat exchangers in the power optics components. Since the characteristic dimension of stress concentrators in cooled power optics elements lies in the range of characteristic linear dimensions of the faces and edges of the porous heat exchangers, the proposed formulation of the problem should give results accurate within a small coefficient of the order of unity. The analysis is based on equations of uncoupled thermoelasticity. It is shown that the temperature differential should not exceed values of the order of 10-100°C to keep stress concentrations below the yield stress in porous heat exchangers, or to keep thermal deformation below 1/20 of the wavelength of CO<sub>2</sub> laser emission. References 3 Russian. [82-6610]

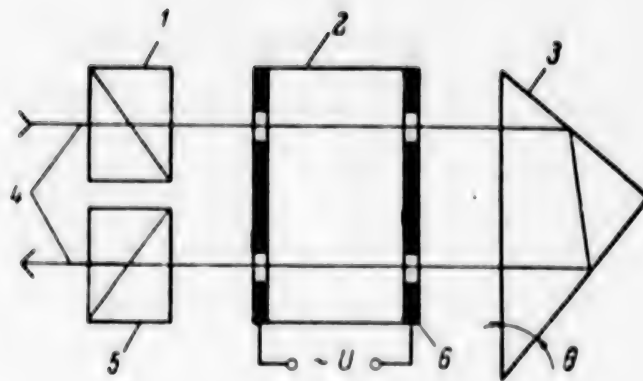
UDC 535.89

#### ELECTRO-OPTICAL MODULATOR WITH TOTAL REFLECTING PRISM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 5, Nov 81  
(manuscript received 5 Jun 80) pp 904-906

DAL'CHENKO, P. G., DZYUBENKO, M. I., NESTRIZHENKO, Yu. A. and SHEVCHENKO, V. V.

[Abstract] A two-pass polarization electro-optical modulator is described in which the number of optical elements is minimized (see diagram). The functions of phase plate and reflector are combined in the right-angled total reflecting prism. The phase advance necessary for orthogonally polarized components of light to ensure operation on the linear section of the modulation characteristic is attained upon two reflections from the orthogonal faces of the prism if the plane of polarization of the light beam incident on the prism makes an angle of 45° with the normal to the plane of incidence. Basic computational data are given that are necessary for designing and constructing such a prism. Experimental results are given for a modulator with BK-10 optical glass prism. The reduced number of optical elements gives the described modulator a number of advantages over conventional polarization electro-optical modulators such as reduced parasitic light losses, smaller overall dimensions, simpler construction and utilization, and improved reliability. [Diagram on following page.]



1--polarizer; 2--electro-optical crystal;  
 3--total reflection prism; 4--light beam;  
 5--analyzer; 6--semitransparent electrodes.

Figures 3, references 4 Russian.  
 [90-6610]

## PLASMA PHYSICS

### INTENSE ELECTRON FLUX ACCELERATION BY HIGH-AMPLITUDE PLASMA WAVE FIELD

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 11, Nov 81  
(manuscript received 26 Jan 81) pp 2446-2449

KUZELEV, M. V., RUKHADZE, A. A. and FILIPPYCHEV, D. S., Physics Institute  
imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The effects that are usually studied in plasma electronics problems involve transfer of the energy of directed motion of electron fluxes to some type of electromagnetic wave. In this paper, the authors investigate the reverse situation of efficient electron acceleration in the field of a high-amplitude wave. The analysis is based on the following boundary value problem. A normal monochromatic waveguide mode with frequency less than the plasma frequency is incident on the inlet of a semi-infinite waveguide of given radius filled with cold plasma. A monoenergetic tubular electron beam with average radius smaller than that of the waveguide and thickness much less than the radius is injected in the initial section along the waveguide axis. The whole system is placed in a strong longitudinal magnetic field. The structure of the resultant field in the waveguide is studied, assuming that wave amplitude varies weakly over a wavelength. The results show that high-current systems can be used for efficient acceleration of electron beams. This effect is possible not only in a plasma waveguide, but in periodic structures as well. Figures 3, references 4 Russian.  
[66-6610]

### RELATIVISTIC RIBBON ELECTRON BEAM IN SELF-FOCUSING STATE

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 16,  
No 5, Sep-Oct 81 (manuscript received 9 Jan 81) pp 397-401

AKOPOV, R. A., ANTABLYAN, O. G. and KHANIKYANTS, Ye. K., Scientific  
Research Institute of Physics of Condensed Media, Yerevan State University

[Abstract] A focused relativistic ribbon electron beam can be used to produce an extended plasma for doing experiments on stimulated emission of multiply charged ions. This paper describes experiments on focusing such a beam to



produce a dense multiply charged plasma on an electron accelerator with beam current of about 35 kA, electron energy of 0.5 MeV utilizing explosive emission of a vacuum diode. The cathode was rectangular with a triangular groove on the vertex 4 mm wide with vertex angle of  $90^\circ$ . Length of the working section of the cathode was 20 mm. The beam generated in the accelerating gap was coupled out through a transparent anode and injected into a drift chamber where a foil showed the beam profile. The degree of beam focusing was evaluated by the ratio of the total current to the cross section of the beam at a given point. It was found that maximum beam density of about  $0.4 \text{ MA/cm}^2$  was attained with an aluminum foil anode with base angle of  $45^\circ$ . Figures 3, references 7: 3 Russian, 4 Western.  
[84-6610]

## STRESS, STRAIN AND DEFORMATION

UDC 533+539

### LOW-FREQUENCY SEISMIC BODY WAVE EXCITATION MECHANISM IN UNDERGROUND BLAST

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
No 5(129), Sep-Oct 81 (manuscript received 10 Sep 80) pp 153-155

RODIONOV, V. N., Moscow

[Abstract] An examination is made of a mechanism that generates an elastic dilatational wave that is longitudinal close to the axis of symmetry of an underground blast. The maximum amplitude is estimated for such a wave formed when the load is relieved on an elastic half-space. It is shown that the condition for effective excitation of such an unloading wave is  $2v_0/g \gg \theta$ , where  $v_0$  is the initial velocity of the displaced rock,  $g$  is acceleration due to gravity, and  $\theta$  is the minimum time of action for establishing equilibrium after action of a concentrated force. The proposed mechanism must be taken into consideration when evaluating the amplitude of seismic waves at great distances.

References 3 Russian.

[70-6610]

UDC 621.378.325

### STATISTICAL PECULIARITIES OF OPTICAL BULK BREAKDOWN OF GLASS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 11, Nov 81  
(manuscript received 14 Nov 80) pp 2345-2349

BEBCHUK, A. S. and ULANOV, S. F., Scientific Research Institute of Organic Intermediates and Dyes, Moscow

[Abstract] An investigation is made of the way that the probability of optical volumetric breakdown depends on radiation intensity for TF-5 optical glass as a medium simulating the properties of glasses and liquid solvents. The emission source was a ruby laser with pulse duration of 12 ns. The radiation was focused into the specimen by a microscope objective lens. Intensity distribution in the cross section of the caustic was close to gaussian, and the size of

the caustic was close to the diffraction limit. Incident power was varied by calibrated light filters. The energy of each pulse was measured with relative accuracy of about 1%. A statistical model is proposed for the probability of bulk optical breakdown of glass as a function of radiation intensity that accounts for intensity distribution in the vicinity of the caustic and agrees with experimental data. The concentration of objects that initiate breakdown is determined. Possible mechanisms of optical breakdown of transparent media are discussed, and it is shown that when the intensity threshold of breakdown is constant, the mechanism of breakdown on absorbing inhomogeneities is consistent with experimental results. Avalanche impact ionization leading to breakdown is unlikely as a mechanism according to the results of this study, and can occur only when the "seed" electron of the avalanche is stimulated by the light field from a localized state. A necessary condition for such a mechanism is concentration of localized electron states at least equal to the average concentration of initiating objects in the transparent dielectric. However, the described experimental technique cannot distinguish between mechanisms of breakdown on absorbing inhomogeneities and by impact ionization. Figures 2, references 15: 11 Russian, 4 Western.  
[66-6610]

CALCULATING VARIATIONS OF CONJUGATE VARIABLES ALONG IMPULSE TRANSFER  
TRAJECTORIES IN CENTRAL GRAVITATIONAL FIELD

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA  
in Russian No 6, Nov-Dec 81 (manuscript received 25 Nov 80) pp 30-33

GLAZKOV, A. I.

[Abstract] A problem arises in astrodynamics of finding multiple-impulse transfers with minimum characteristic velocity and a fixed number of impulses. The author considers an indirect method of optimization: improving non-optimum transfers by selecting displacements in phase space in such a way that the conjugate variables at the instants of impulse application have values satisfying the necessary conditions of optimality. Formulas are derived for calculating variations of variables that conjugate to the radius vector and velocity vector at points of impulse application on the given transfer trajectory. The proposed exact formulas improve accuracy and convergence of calculations in iteration methods used for finding steady-state solutions without numerical differentiation in central gravitational fields. References 3 Russian. [77-6610]

THERMOACOUSTIC EFFECT OF RADIATION BEAMS IN HETEROGENEOUS MEDIA

Leningrad ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 51, No 11, Nov 81  
(manuscript received 16 Feb 81) pp 2449-2450

KALINICHENKO, A. I. and LAZURIK, V. T., Khar'kov State University  
imeni A. M. Gor'kiy

[Abstract] Equations of radiative thermoacoustics derived and analyzed in previous research for the case of homogeneous isotropic media can be used to compute the acoustic response in some important cases and to make comparisons with experimental data. The coefficient of proportionality between the density of absorbed energy and the resultant thermoelastic pressure (Grüneisen parameter) in these equations depends only on the properties of matter, and is independent

of radiation characteristics. For powder metallurgy materials, composites, emulsions, suspensions and the like in which the components have differing thermophysical properties, the Gruneisen parameter may be considerably dependent on the characteristics of the incident radiation. Therefore the authors consider the feasibility of introducing an effective Gruneisen parameter for a heterogeneous medium. An expression for such a parameter is derived and analyzed for a two-component medium consisting of a homogeneous isotropic material with spherical inclusions of another material. It is shown that such an effective Gruneisen parameter may be much larger or smaller than that of either component. Thus, heterogeneous media can be varied by changing components and their concentrations to give combinations of absorptivity and Gruneisen parameters that are impossible for homogeneous media. In the case of optical, neutron or gamma radiation, the ratio of energy densities absorbed in the two components may be very large, and the effective Gruneisen parameter may be quite dependent on particle energy. On the other hand, in the case of exposure to fast charged particles the effective Gruneisen parameter is of the order of the Gruneisen parameter of the homogeneous isotropic matrix, and does not depend on the particle energy. References 5: 3 Russian, 2 Western.

[66-6610]



## MATHEMATICS

UDC 517.52

### $L_1$ -CONVERGENCE OF FOURIER SERIES WITH RESPECT TO WALSH-KACZMARZ SYSTEM

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA  
in Russian No 6, Nov-Dec 81 (manuscript received 4 Jan 80) pp 3-6

SKVORTSOV, V. A.

[Abstract] An examination is made of series with respect to the Walsh system in numerations obtained from the Paley numeration by using so-called piecewise-linear permutations, extending the analysis of the Walsh-Kaczmarz system. It is proved that the Dini-Lipschitz theorem on convergence in  $L_1$ -space applies to Fourier series with respect to such systems. References 8: 4 Russian, 4 Western.  
[77-6610]

UDC 519.21

### ASYMPTOTIC ANALYSIS OF MARKOV SYSTEMS WITH 'FAST SERVICING'

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI in Russian No 11, Nov 81 (manuscript received 10 Oct 80) pp 5-8

GILEVICH, Ya., Kiev State University

[Abstract] An analysis is made of asymptotic behavior of the time of first loss of a customer in Markov queuing systems with controllable incoming flow. A queuing system is considered that consists of  $m$  different servers without waiting spots. A customer goes to the server with minimum number among those that are not busy. A customer that is blocked by all servers leaves the system. The incoming stream is controlled by some ergodic Markov process with a finite number of states. References 7 Russian.  
[83-6610]

## ADAPTIVE OPTIMUM CONTROL OF CERTAIN MARKOV PROCESSES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 261, No 2, Nov 81  
(manuscript received 23 Apr 81) pp 271-275

GORDIYENKO, Ye. I.

[Abstract] An analysis is made of controlled Markov processes with discrete time that are defined by the relation  $x_t = \phi(x_{t-1}, \alpha_t, \xi_t)$ ,  $t = 1, 2, \dots$ , where  $x_t \in X$  is the state of the process at time  $t$ , control  $\alpha_t$  at time  $t$  is selected from the set of controls  $A(x_{t-1})$  that depends on the preceding state of the process,  $\xi_1, \xi_2, \dots$  is a sequence of independent equally distributed random elements in some known measurable space. It is assumed that the distribution of random element  $\xi \equiv \xi_1$  is unknown, but the realizations of random elements  $\xi_1, \xi_2, \dots$  can be observed together with the state of the process in implementation of an arbitrary control strategy. An adaptive strategy is constructed that optimizes the average income per unit of time. References 3: 2 Russian, 1 Western.  
[88-6610]

UDC 519.8

## PROPERTY OF PRIORITY-GENERATING FUNCTIONS

Minsk IZVESTIYA AKADEMII NAUK BSSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK  
in Russian No 6, Nov-Dec 81 (manuscript received 10 Feb 81) pp 15-18

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[Abstract] Let  $\hat{P}$  be the set of all permutations  $\pi_r = (i_1, i_2, \dots, i_r)$ ,  $r = \overline{1, n}$  of elements of the set  $N = \{1, 2, \dots, n\}$ . The number  $r$  is called the length of permutation  $\pi_r \in \hat{P}$ . The symbol  $\{\pi\}$  denotes the set of all elements of  $N$  that form the permutation  $\pi \in \hat{P}$ , and  $\pi_0$  denotes the permutation such that  $\{\pi_0\} = \emptyset$ . If  $\pi(1) = (i_1, i_2, \dots, i_r)$  and  $\pi(2) = (j_1, j_2, \dots, j_s)$  are permutations from  $\hat{P}$  such that the intersection of  $\{\pi(1)\}$  and  $\{\pi(2)\}$  is the empty set, then  $(\pi(1), \pi(2))$  denotes the permutation  $\pi = (i_1, i_2, \dots, i_r, j_1, j_2, \dots, j_s)$ . Let  $P$  be a subset of  $\hat{P}$ . We use  $Q(P)$  to denote the set of those and only those permutations  $\tilde{\pi} \in \hat{P}$  for which there is a permutation  $\pi$  in  $P$  that has form  $\pi = (\pi(1), \tilde{\pi}, \pi(2))$ , where  $\pi(1), \pi(2)$  are members of the join of  $\hat{P}$  and  $\pi_0$ . The real function  $F(\pi)$  is defined on the set  $P'$  that is a subset of  $\hat{P}$ . The function  $F(\pi)$  is called a priority-generating function on the set  $P$  that is a subset of  $P'$  if it satisfies the following conditions. A real function  $\omega(\pi)$  can be defined on set  $Q(P)$  such that for any permutations  $\pi' = (\pi(1), \pi(a), \pi(b), \pi(2))$  and  $\pi'' = (\pi(1), \pi(a), \pi(b), \pi(2))$  that belong to  $P$ , the inequality  $\omega(\pi(a)) > \omega(\pi(b))$  implies  $F(\pi') \leq F(\pi'')$ , and the equality  $\omega(\pi(a)) = \omega(\pi(b))$  implies  $F(\pi') = F(\pi'')$ . The function  $\omega(\pi)$  defined in this way is called a priority function for  $F(\pi)$ . The author proves a

certain property of priority-generating functions that is then used to study the limits of applicability of a known algorithm for solving problems of minimizing such functions. The priority function  $\omega(\pi)$  is said to be self-limited on permutation  $\pi \in Q(P)$  if for any permutations  $\pi(a)$ ,  $\pi(b)$  such that  $(\pi(a), \pi(b)) = \pi$ , the condition

$$\min[\omega(\pi(a)), \omega(\pi(b))] < \omega(\pi) < \max[\omega(\pi(a)), \omega(\pi(b))]$$

is satisfied. Priority function  $\omega(\pi)$  is said to be self-limited if it is self-limited on any permutation from  $Q(P)$ . It is proved that if  $F(\pi)$  is a priority-generating function on set  $P$ , then its self-limited function exists on set  $Q(P)$ . A procedure is given for constructing a new priority function  $\omega'(\pi)$  for function  $F(\pi)$  that will be self-limited. References 4 Russian. [86-6610]

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#### SOME DISCRETE GAMES WITH FIXED TIME

Baku DOKLADY AKADEMII NAUK AZERBAIDZHANSKOY SSR in Russian Vol 37, No 11, Nov 81 (manuscript received 26 Jan 81) pp 7-10

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[Abstract] The author considers discrete linear games of pursuit with fixed time and with incomplete information. The system to be controlled is

$$z(k+1) = A_z(k) - B_u(k) + C_v(k), \quad z(0) = z_0 \quad (1)$$

where  $k = 0, 1, \dots, H-1$ ,  $z(k) \in R^n$ ,  $A$ ,  $B$ ,  $C$  are the matrices  $n \times n$ ,  $p \times n$ ,  $q \times n$  respectively. Controls  $u(k)$ ,  $v(k)$  on each  $k$ -th step belong respectively to  $P_k$ ,  $Q_k$ ,  $k = 0, 1, \dots, H-1$ , where  $P_k$  and  $Q_k$  are compact sets that are subsets of  $R^p$  and  $R^q$  respectively,  $u(k) \in P_k$ ,  $v(k) \in Q_k$ . Let  $\pi$  be a non-zero linear operator that maps from  $R^n$  into  $R^m$ . The notation  $L = R^n$  is introduced. Let  $\phi(y)$  be a continuous scalar function with  $y \in L$ . The motion of vector  $z(k)$  begins in step  $k = 0$  from initial state  $z_0$  and takes place at  $k = 0, 1, \dots, H-1$  under the action of controls  $u(k)$  and  $v(k)$ . If the initial state of the game is given, the quality of admissible controls of the players is determined by the value of  $\phi(\pi z(H))$ , where  $z(k)$  is a solution of system (1) corresponding to condition  $z(0) = z_0$  and controls  $u(k)$  and  $v(k)$ . The choice of vector  $v(k)$  is available to the first player, and the choice of  $u(k)$  is available to the second player. The goal of the first player is to minimize  $\phi(\pi z(H))$ , while the second player's goal is to maximize this functional. The game is considered from the standpoint of the first player when the second player chooses control  $v(k)$  arbitrarily, and the first player has limited information. Effective methods are constructed for getting guaranteed and optimum results. References 3 Russian. [80-6610]

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